U. S. DEPARTMENT OF AGRICULTURE

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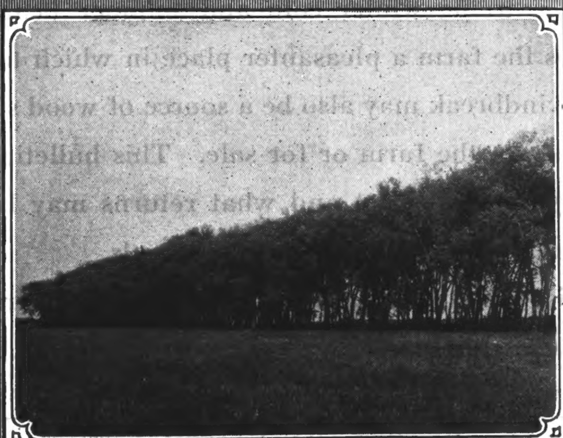
The WINDBREAK AS A FARM ASSET



WINDBREAKS are, in more ways than one, a farm asset. They tend to prevent the soil from drying out quickly and they protect grain and orchards from mechanical injury by the wind. A belt of trees by the farm buildings protects them from extreme winter cold and summer heat, and makes the farm a pleasanter place in which to live. The windbreak may also be a source of wood supply for use on the farm or for sale. This bulletin tells how windbreaks act and what returns may be expected from them in dollars and cents.

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THE WINDBREAK AS A FARM ASSET.

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WINDBREAKS ON THE PRAIRIES.

WHEN the prairie regions of the Middle West[1] were first developed the lack of trees was felt severely. The clear sweep of the winds across the flat plains was a great hindrance to agriculture, for the soil was dried out quickly by evaporation, and grain was lodged and orchards injured by the mechanical force of the wind. Windbreaks were the only remedy, and thousands of miles of them were planted along roads and farm division lines. The effect of this planting, though only gradually felt, was very distinct; farming and living conditions became more favorable throughout the whole region.

Considerable planting is still being done, but probably no more than enough to counterbalance the cutting in windbreaks already planted. Of course the need of windbreaks is not so acute now as it has been in the past, but some extension of the planting in this region is desirable, at least enough to protect the new areas which have been put under cultivation.

WHAT IS A WINDBREAK?

Any body of trees which gives protection to buildings or crops may be called a windbreak. This bulletin has to do, however, only with belts of trees planted about fields and farm buildings, especially for the purpose of breaking the force of the wind. The typical windbreak is a belt consisting of from six to eight rows of trees and usually from a quarter of a mile to a mile in length.

HOW A WINDBREAK PROTECTS.

CHECKING WIND MOVEMENT.

The influence of a timber windbreak upon air currents is purely mechanical. Its effectiveness depends, therefore, upon how nearly

[1] The Middle West includes the States of Illinois, Iowa, Minnesota, North Dakota, South Dakota, Nebraska, and Kansas.

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impenetrable it is. The ordinary windbreak does not provide an absolute barrier to the wind; a certain amount of air forces its way between the branches and foliage of the trees, so that the movement of the air on the leeward side is not completely stopped but only greatly reduced. When windbreaks composed of such trees as cottonwood become old, wide openings are left between the bare trunks and more wind gets through near the ground than higher up.[1] Such windbreaks can be made efficient only by underplanting the cottonwood with other trees or shrubs.

An ideal windbreak for checking wind currents would have the contour of an earth dam. In the central rows would be planted

FIG. 1.—On irrigated lands in western Colorado (Mesa County), the Lombardy poplar, a close relative of the cottonwood, grows thriftily, and is used for the protection of orchards.

the tallest trees, such as cottonwood; on either side, rows of shorter trees, such as ash and locust; and outside of these, low bushes or cedars. Such a windbreak would not be easily penetrated, and its inclined surface would divert the air currents upward and relieve the horizontal wind pressure.

Breaking the mechanical force of the wind benefits the farmer most directly by protecting his grain crops and his orchard. The value of the windbreak in giving this protection is, of course, difficult to measure in dollars and cents, but where winds are at all frequent such protection alone may be equal to the rental of the ground occupied by the trees. In one case in southern Minnesota a windbreak,

[1] A dense mulberry hedge of a single row may offer quite as much resistance to the wind near the ground as several rows of open-growing locust or cottonwood.

80 rods long and about 28 feet high along the side of a cornfield, afforded complete protection for a strip about 10 rods wide during a wind blowing at 50 miles an hour. On the unprotected part of the field the wind blew down half the corn and bent the remainder halfway, the damage beginning at the edge of the 10-rod strip and increasing until it was greatest in that part of the field farthest from the windbreak. The corn was in the milk stage at the time of the high wind and did not produce more than a third of a crop on the damaged area. On the protected portion the total saving was 260 bushels, or the full crop of 6 acres, whereas the windbreak occupied only 2 acres.

FIG. 2.—Corn to the north of a cottonwood grove is badly damaged by shade in a few rows adjacent to the trees.

Movement of the topsoil also may be checked and dust storms prevented by breaking the force of the wind. For this reason windbreaks are of immense benefit in sandy regions or regions where the soil is very fine.

Added to the crop and soil protection there is the personal comfort to be derived from protection from wind about the farm and home and along public roads. Furthermore, a protected home is heated in winter more readily, and hence more cheaply, than one exposed to the wind.

REDUCING EVAPORATION.

There is no part of the United States, except small areas in the Appalachian and Cascade Mountains, which normally obtains more precipitation than is needed for growing the best crops. The farmer

usually plows, cultivates, and mulches with the object of conserving every drop of water that may reach the soil during the year. In the "dry-farming" regions of the West these conservation measures are carried farthest. Here it may be necessary to save the moisture of two seasons to grow a single crop.

Anything which helps to conserve the moisture of the soil is of direct benefit to the farmer. The windbreak has this effect in a marked degree. The drying power of the wind is reduced by the windbreak very nearly in the same proportion as its velocity. In the immediate lee of the most effective windbreaks evaporation is reduced as much as 65 per cent. Farther from the trees the

FIG. 3.—Alfalfa grows almost to the base of honey-locust trees.

reduction is less. The amount of reduction depends not only upon the density and proximity of the windbreak, but upon whether the field is fallow or in crops. The saving in moisture is least when the field is fallow, so that the only reduction is in the direct evaporation from the soil; it is greatest when the field is in crops, so that there is a reduction not only in the direct evaporation from the soil but also in the evaporation from the leaves of the crops.

The more frequently winds occur in any locality during the growing season, and the greater their velocity and drying power, the more important it is to use every means of preventing evaporation. Windbreaks are especially valuable, therefore, in the Middle West, where

hot, dry winds, often of high velocity, are of frequent occurrence during the summer months, and in Montana and the Dakotas, where the warm west winds of the winter and early spring, known as "chinooks," do great damage to winter wheat and orchards.

EFFECT ON TEMPERATURE.

The farmer who has cultivated crops on a hot summer day need hardly be told that the warmest part of his field is the portion which is sheltered from the wind. In the lee of the windbreak there is not only no breeze to cool the body and reduce what is known as the

FIG. 4.—The branches of ash are small and short, and the tree does little damage by shading crops.

"sensible temperature," but the actual temperature of the air is raised. Tests with a thermometer have shown that the area which is protected by a windbreak may be several degrees warmer during the day and several degrees cooler during the night than adjacent areas not protected.

Such crops as corn are benefited very greatly by warm, sultry days. The windbreak helps to create these conditions and offsets to some extent the effect of cold, cloudy weather. The cooling effect at night is of course unfavorable to growth then; but the night is a period of comparative rest, so that the nocturnal cooling off is far

more than counterbalanced by the higher temperatures secured during the day.

Windbreaks may appear undesirable for the protection of orchards in blossom or garden crops which are not hardy, because the danger of still frost seems increased by the stagnation of the air on the lee side. The added danger is more apparent than real, however, for still frosts only occur when there is practically no wind, and a windbreak can then have little effect one way or the other. Furthermore, complete stagnation of the air may be helpful rather than harmful if smudging is resorted to.

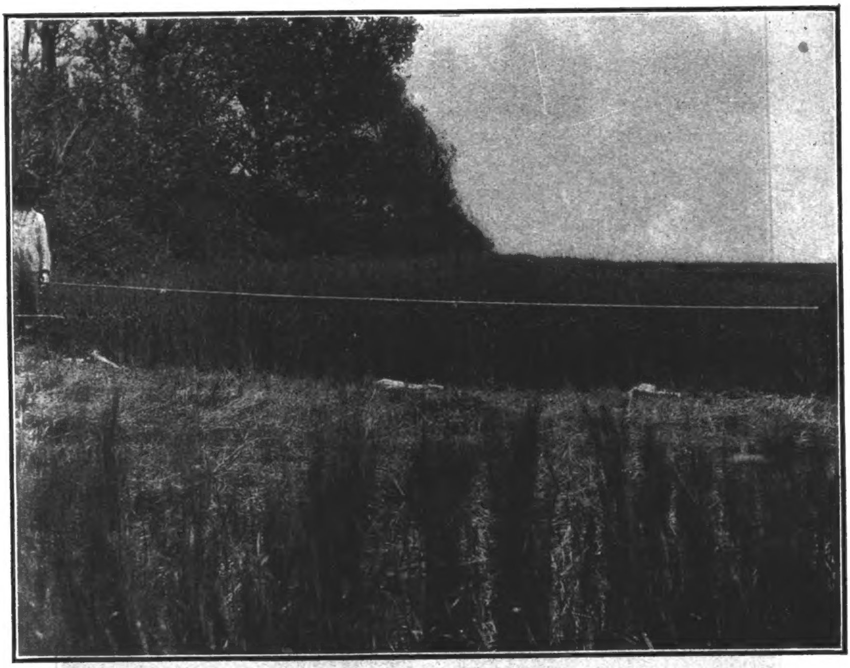

FIG. 5.—Wheat near the trees has been benefited by the covering afforded where snow drifted in the lee of the windbreak.

The freezing which often causes the most severe damage to orchards is that which follows a cold rain or late snow. During such a freeze the damage to blossoms is greatly reduced by protection from wind; for evaporation which produces a rapid cooling increases in proportion to wind velocity. During a freeze of this kind in Nebraska in 1908, fully protected orchards yielded crops many times as heavy as those without exterior protection, and even the leeward side of individual trees exposed to the wind suffered much less damage than the windward side. It is noteworthy also that the one storm of rain and snow, with a temperature of 28 degrees, did all the damage during the season, and that later frosts with lower temperatures did not affect the orchards.

EFFECT OF THE WINDBREAK ON YIELD OF CROPS.

The effect of a windbreak on crops is not beneficial in every respect. There are certain ways in which it is plainly injurious. Trees in a windbreak always spread their roots extensively into the adjoining fields in search of moisture; and they take not only the moisture but some of the nitrogen content of the soil. Furthermore, by shading the ground they may prevent crops from developing properly.[1]

Whether the total effect of a windbreak is good or bad depends upon whether the benefits derived from its influence on wind movement, temperature, and evaporation are greater or less than the injury resulting from the sapping and shading of the ground near by.

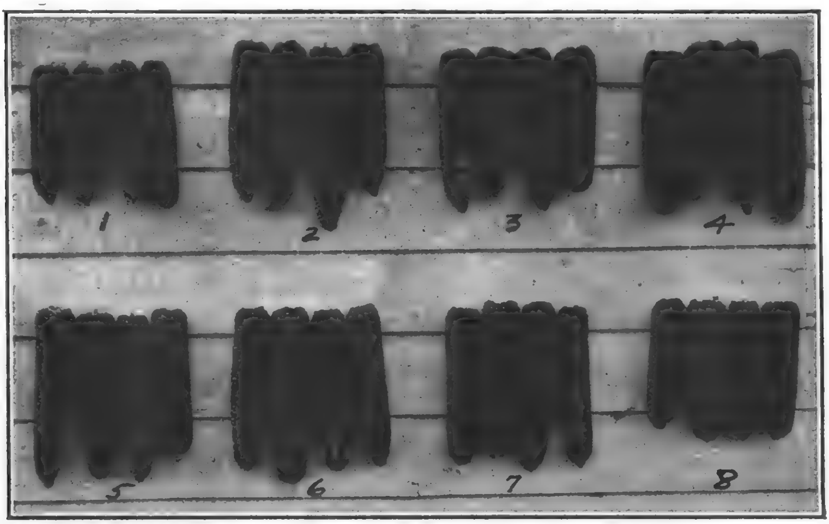

Fig. 6.—Effect of windbreak protection on quality of corn. *1,* In rows shaded by trees; *2–7,* average maximum ears from protected rows; *8,* ears from unprotected portion of field.

To determine the total effect, crop measurements have been made in Nebraska, Kansas, Iowa, and Minnesota. Average rather than exceptional conditions were measured, the object being to discover the effect of those influences which are continuous and affect every annual crop grown.

Measurements made in fields of small grain indicate that the crop gain in the protected zone is sufficient to offset fully the effects of shading and sapping. In a wheat field protected by a dense windbreak the gain amounted to about 10 bushels per acre where the protection was most complete, and gradually grew less as the distance

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[1] Some crops do better than others when shaded. Seeding crops, such as timothy and alfalfa, are least affected; grains which develop early in the spring, such as oats and wheat, are most affected, and corn occupies an intermediate position.

from the windbreak increased. The total gain was about equal to the amount of grain which could have been grown on the shaded ground near the trees. The season in which the measurements were taken was not of high winds, nor did it lack moisture. It would appear, therefore, that in a windy year when evaporation was high the total gain for the field would much more than balance the loss. In another case, barley on the south of an ash and honey locust windbreak benefited very materially from the accumulation of snow in the lee of the trees and the conservation of this moisture. Here cultivation was possible within 4 feet of the stems of the trees, so that the increased

FIG. 7.—Effect of favorable atmospheric conditions on growth of corn plants and yield of fodder. On right, in protected zone (weight, 81 pounds); on left, in unprotected zone (weight, 42 pounds).

yield of the field, amounting to about 14 bushels per acre at the highest point, was practically clear gain. The total gain for the whole field amounted to the yield of a strip of ground as long as the windbreak, and three times as wide as its height. In other words, had the windbreak, which was 20 feet high, occupied a strip of ground 60 feet wide, the gain in the field crop would have paid the rental on all of this ground.

The corn crops showed more consistent and marked benefits from protection than any others. In the region concerned the summer winds are almost wholly from the south, so that the only effective

rows and belts extend in an east-west direction. The effect on corn was very marked for a short distance on the south side of such windbreaks and for a much greater distance on the north side. Fields of young corn showed much better growth in the area protected and warmed by the windbreak. The effect was visible to the eye early in the season, which was rather cool. Height measurements on one field showed the plants to be 4½ feet high in the first 18 rows next to the windbreak, while beyond this protected zone the height was only 2½ feet. This luxuriant growth was still in evidence at the end of the season, and not only produced more fodder, but bigger and heavier ears. The field showed a production of 59 bushels to the acre in the protected part and only 41 bushels in the exposed part. The net gain, including the area shaded by the grove, was equivalent to the yield of a strip twice as wide as the height of the trees, which were 38 feet high. The increased yield paid, then, for a strip 76 feet wide. The windbreak happened to be wider than this, but need not have been to afford the same amount of protection.

With ordinary field crops the farmer may count on a benefit from windbreak protection which will make the loss of the area occupied by the trees negligible. Under Middle Western conditions a windbreak whose width does not exceed two or three times its height will more than pay for itself, regardless of the timber which it may produce. Farther east the same kind of influence and benefit will exist, though in a less marked degree, and a greater direct return may be expected from growing the timber for its own value, so that the need of even a slight amount of protection should make windbreak planting attractive.

WHERE AND WHAT TO PLANT.

In any region the windbreak should be so laid out as to offer the greatest resistance to damaging winds and to protect the greatest area. This simply means having the belt or row at right angles to the prevailing winds.

In most of the Middle West the principal wind to be feared is the drying south wind of summer. Where the soil is reasonably moist, a cottonwood belt, extending east and west across the southern boundary of the farm, is preeminently the windbreak for this region. It may be supplemented by other east-west windbreaks or hedges, dividing the farm into lots and fields, and made up of mulberry or osage orange, green ash, or locust, depending upon the moisture of the soil. The cottonwood windbreak is recommended because it so quickly attains great height and produces so much wood for fuel. After it has grown, however, it may need underplanting or side planting to fill the gaps in the lower story. The underplanting, if any, must be done within a few years after the planting of the cotton-

wood. For this purpose green ash or red oak is recommended. On the drier situations the main planting must be done with some of the more drought-resistant species which do not attain such great height. Green ash or locust for the main belt and osage orange for the hedge can not be excelled.

Even with the low rainfall of this region, tree growing has proved entirely possible when preceded by thorough deep plowing of the soil and fallowing for a year or more. Green ash stands out in past experience as the most hardy tree for the region, but hackberry, elm, honey locust, and even cottonwood give good assurance of success if

FIG. 8.—When mature, cottonwood must be underplanted if the belt is to retain its efficiency.

well cultivated for several years after planting. Western yellow pine may also be used, but only on sandy soil or gravelly, well-drained knolls in the region of heavier soils.

In the western part of this region more attention may have to be given to westerly winds, and the direction of the rows changed. In eastern Colorado, for instance, the windbreak must be planted so as to afford protection from the spring winds from the west, which are often very damaging.

On the northern prairies (western Minnesota and the Dakotas) southerly summer winds are not so much felt as the westerlies. Here windbreaks should be mainly north-south ones, although some pro-

tection on both the north and the south sides of the farm may be needed. Scotch and Norway pines, Colorado blue spruce, and Black Hills spruce are recommended where moisture is sufficient for them, because they give so much better winter protection than the hardwoods. On drier situations western yellow pine may be substituted for the Norway.

In the Lake States practically all damaging winds are from the west, although the orchard may need just as much protection from the easterly winds which usually precede and accompany a storm. White pine is recommended above all other species, because of its rapid growth and high timber value, which justify its planting in wide belts or groves. The planting of white cedar along the edges of older white-pine belts will greatly increase the efficiency of the existing windbreak. On the poorer soils Norway or Scotch pines may be used instead of white pine.

In the Eastern States the situation is essentially the same as in the Lake States. White pine may be generally used, and white and Norway spruces and white cedar may be used in mixture or to strengthen the older windbreak on the sides.

In the Southwest the choice of species is very limited, and in typically dry situations possibly nothing can be made to succeed which has greater value than sagebrush in the form of hedges placed at frequent intervals. With a little more moisture the native evergreens, piñon, alligator juniper, and cedars may be made to grow. With irrigation the species used in the Middle West can undoubtedly be utilized to good advantage. If possible, the windbreaks should extend northwest-southeast.

In California citrus orchards and other valuable crops need protection on all sides. Protection from the northerly "Santa Ana" is probably most essential to grains and other field crops. For all of these purposes Monterey cypress, Monterey pine, and eucalypts have proved very valuable.

In the Columbia River region of the Northwest, Carolina and Lombardy poplars and cottonwood are very efficient for the protection of orchards and crops against the mountain winds, usually of easterly origin. Even small willows have been used to good advantage in checking the drifting of sand.

GROUND SPACE NECESSARY.

The belt of trees forming a windbreak needs the use of a certain amount of ground beyond that on which it actually stands. There must be space for the roots to spread out in search of soil nourishment and moisture. It should be remembered that the row of trees is a productive agent quite as much as a row of corn and may need just as much growing space in proportion to its height. Some species of trees, of course, spread their roots wider than others and need more space. Of those commonly planted, mulberry, honey

locust, and osage orange spread the farthest in proportion to their height, and green ash spreads the least. Cottonwood does not spread its roots so far as is generally supposed.

Cultivation tends to limit the spread of the roots by making more moisture available near the trees, though deep plowing or cutting the roots restricts the root extension at the expense of the growth of the trees themselves. On the other hand, competition between trees, where several rows are planted together, tends to make those on the outside of the belt push their roots farther out into the open ground.

The width of the strip of ground to be allowed the windbreak may be figured at from one and one-fourth to twice the height of the trees; for instance, a single row of trees 50 feet high should be allowed a strip of ground from 62 to 100 feet wide.

DIRECT RETURNS FROM PLANTING.

In addition to affording protection to crops and buildings, the windbreak usually has considerable value as a source of wood supply for use on the farm or for sale. In the following estimates of the timber value of various kinds of windbreaks the acreage on which the figures are based includes not only the ground actually occupied by the trees but also that which is shaded and sapped. The estimates are for annual yields per acre for the average number of years required to mature each species.

Cottonwood rows and narrow belts, planted on fairly moist bottom lands, yield from 60 to over 200 cubic feet of wood per acre-year, a fair average being about 130 cubic feet. This means nearly 1½ cords of fuel per year, but the greatest profit usually results from cutting at the age of about 40 years, when 75 per cent of the entire volume will make lumber. Figuring 5 board feet to each cubic foot, there should then be available, for each year of growth, about 480 board feet, besides one-third of a cord of fuel.

Willows, on thoroughly moist soils, also produce very large yields, but because they do not usually grow to large size their product is best computed as fence posts, some species of willow making fairly durable posts. Average figures for rows and small groves show a production of about 210 fence posts per acre per year, of which 60 per cent, or about 125 posts, will be first and second class posts, the remainder suitable for stays. In terms of fuel, the yield of willow plantations is about 1½ cords per acre, allowance being made in all these calculations for the large area occupied by the roots. Usually willow plantations will have reached their best at the age of about 10 years.

Green ash, which will grow on the driest situations within the region here discussed, gives much smaller yields than cottonwood or willow, even on the best soils, but its product is very useful on the farm and must be rated very high among the timbers that can

be grown in a semiarid region. About 80 fence posts per year is an average yield, 50 per cent of these being firsts and seconds. At least 25 years are required with this species for the best development and returns.

Silver maple, though a fairly rapid grower, has very low value for any purpose and is practically of no value for fence posts. An average yield of one cord of fuel per acre-year may be expected when this species is planted on good agricultural land.

Honey locust will produce valuable fence material even when grown on dry ground, but does its best on deep, moist soil. On the best soils the yields at first are comparatively low, averaging only about 60 fence posts per year; and on dry soils the yields are proportionately less. Honey locust attains its greatest value if cut fairly young and allowed to sprout, the sprouts being very vigorous, and making posts of better average quality than the slow-growing first growth. Such sprouts will give a high yield in 10 or 12 years.

Osage orange is one of the best producers of fence material in the southern part of the plains region and makes an impenetrable hedge while growing. It does not require very much moisture. An average yield of about 90 posts per year may be expected from the acreage occupied by osage orange hedges, 35 per cent of these being firsts and seconds, and even the smaller ones having a good market value because of their durability.

Russian mulberry is another valuable hedge and producer of fence posts when planted on moist sandy land, its yields being among the highest and the product one of good quality. An acre planted to this species may be expected to yield 200 fence posts each year, the crop becoming available after 10 or 12 years.

White pine on soils of good quality and Scotch pine on more sandy soils may be expected to give high and constant yields, at least in northern Iowa, Minnesota, and the States farther east. Because their products are more for the market than for farm use, and because they require a relatively long period to mature, say 40 years, they are likely to make less appeal for windbreak planting than the quick-maturing hardwoods. But these pines give exactly what is needed in the northern region, which is winter protection, and because of this their final high market value should be carefully considered. Either species under favorable conditions is capable of producing 200 cubic feet of wood per acre per year, and an average of 150 cubic feet is not too high for their yield on agricultural lands. This, expressed in board feet, means at the end of 40 years 30,000 feet of lumber per acre, which at present stumpage prices should yield a handsome profit over the cost of planting and care.

Information concerning yields, crop benefits, and other aspects of planting is given in much greater detail in Forest Service Bulletin 86.

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July 2, 1928

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